
Space Weather Technical Forecast

Issued on Sunday, 21 January 2024 at 00:18 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Large Earth-directed CME. Moderate Geomagnetic Storm G2 Likely, Chance G3 Monday 22 January. Risk easing into Tuesday 23 January.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity, as recorded by GOES16, was Low over the UTC day of Saturday 20 January, with occasional C-class flares observed. These flares peaked with an impulsive C5.2 at 20/1434UTC from a possible newly-developing region to the immediate northeast of AR3559 in the northeastern quadrant. The other notable flare of the 24 hours was a long-period C3.5 at 20/0934UTC associated with a filament eruption from the southeast-centre disc.

There were up to eleven sunspot regions noted in the period, including up to three unnumbered regions. The main changes were the emergence and proliferation of spots in AR3562 and AR3560, as well as significant infill in AR3559 in the northeast to become a Eai/Beta.

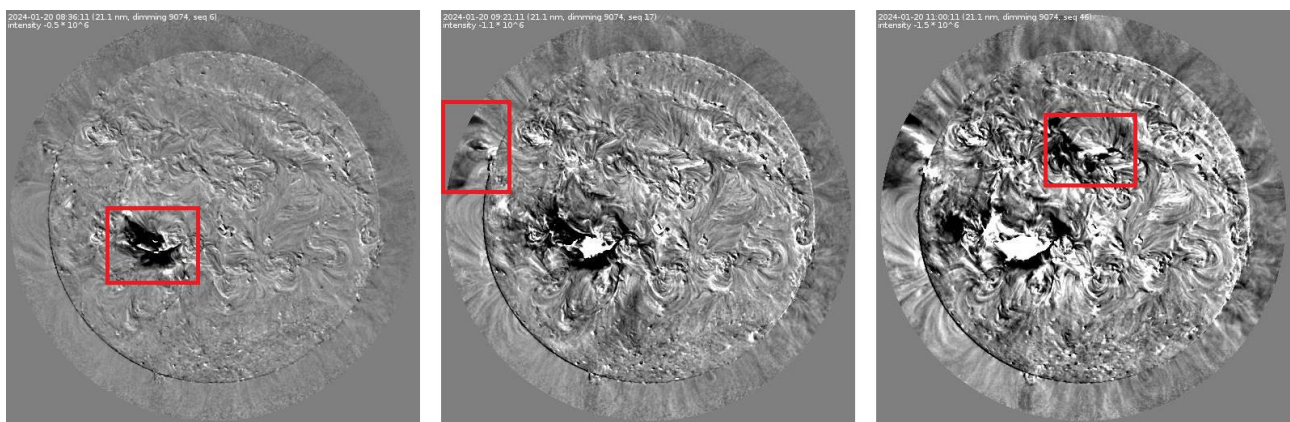


Figure 0: Trio of SIDC ROB-processed time integrated AIA 211 coronal dimmings, showing boxed in red respectively the 20/0840UTC southeast-central filament eruption; a near-concurrent northeast prominence and the 20/1030UTC north central dimming. At the time of writing, only the first of these events features as an Earth-directed CME.

The most notable event of the period was the aforementioned large filament eruption from the central southeast quadrant at 20/0840UTC, with the filament's centroid near S10E10. Possibly polluting this event on coronagraphs was a near-simultaneous prominence eruption from near N20E80. A partial halo seen heading slightly south and east of the Sun-Earth line on subsequent Lasco and STEREO A COR2 imagery interlaces with a more eastward cone from the prominence, although both seem to be travelling at similar speeds which further complicates analyses. A third filament-related disturbance occurred in the north-central disc at 20/1030UTC near N15W00, although H-alpha imagery suggests that the filament responsible remained anchored, and no obvious further contribution to CME ejecta was visible in coronagraph imagery.

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The latest MOSWOC Enlil run suggests an arrival time of the southeast central CME at Earth of 22/1500UTC, however errors in its intervening windspeed (an overly fast background field) mean that arrival around 22/1800UTC is perhaps preferred, which happens to also be more centrally located within the MOSWOC Enlil ensemble. This forecast remains under review given possible interaction with the more eastward CME and possible (self-)corrections to MOSWOC Enlil's handling of fast winds.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by DSCOVR, were roughly constant at Slightly Elevated levels. The solar wind speed showed a very slight waning tendency from 425 to near 400km/s by the period's end. The solar wind density was similar but within its background range of single figures ppcc, while the IMF was at background levels at or below 5nT. The north-south component ranged between +4 and -5nT, with an overall anti-aligned bias. The phi angle was positive (away from the Sun).

The net result of the above solar wind measures was for Quiet geomagnetic activity, with a provisional peak Kp of '2+' seen in the 03-06UTC interval.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux was at Background levels.

GOES16 high energy (greater than 2MeV) electron flux was at Normal Background levels. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold on a steady trend. At 21/0001UTC the 24-hour integrated fluence observation was 1.44e6 integrated pfu.

Four-Day Space Weather Forecast Summary

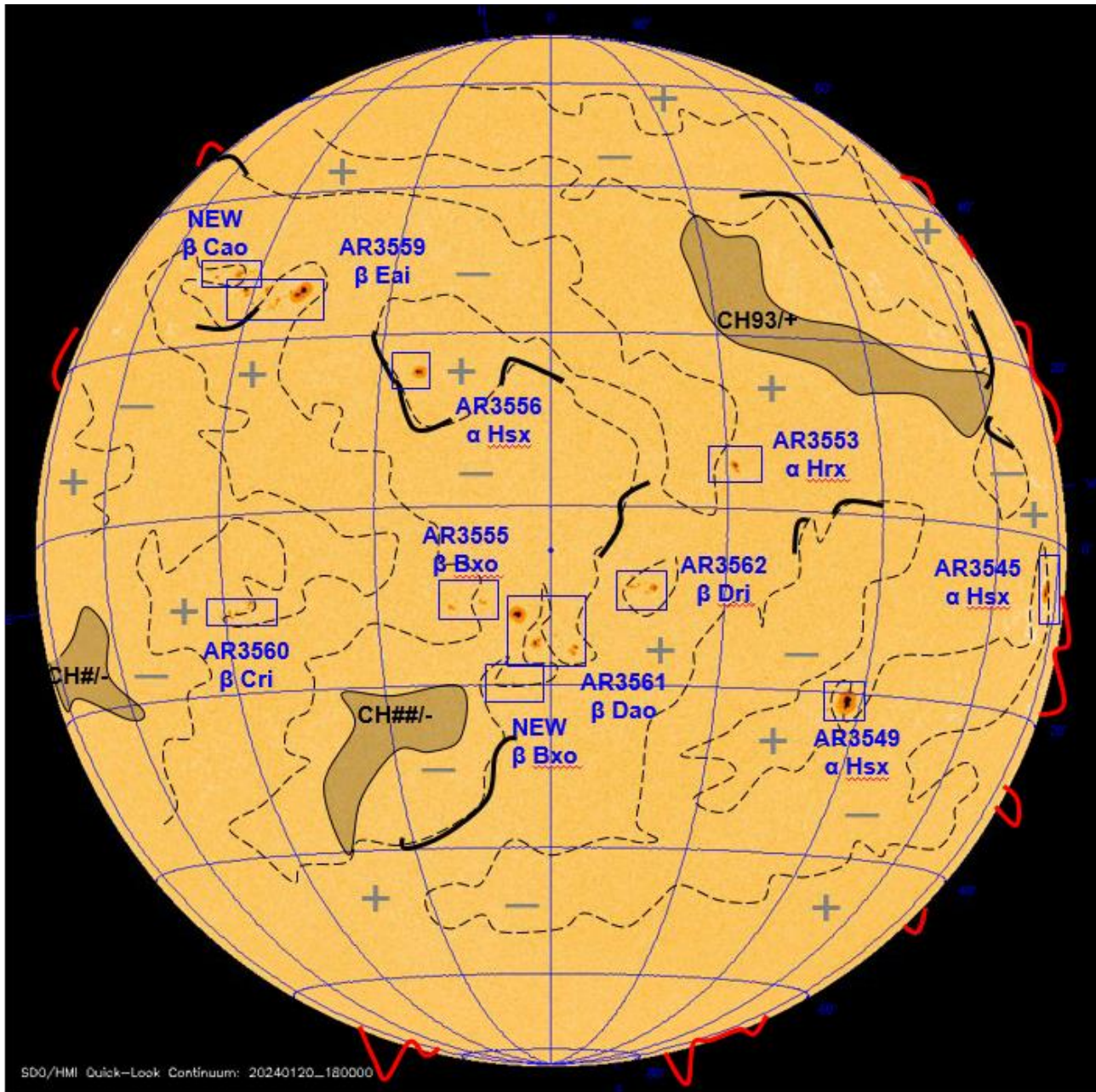
Solar Activity: There is a daily Chance of isolated M-class flares, with a roughly level trend.

Solar Wind / Geomagnetic Activity: A fast wind is due inside the first 24-hour period, giving a Slight Chance of G1 before beginning to wane in the first half of the UTC working week. The CME from the 20/0840UTC southeast-central filament eruption now dominates considerations. A most likely arrival time of 22/1800UTC is suggested, with G2 Likely and with a Chance of G3, continuing into the first half of the UTC day of Tuesday 23 January before abating to Quiet conditions by midweek UTC.

Energetic Particles / Solar Radiation: High energy proton flux is forecast to remain at Background levels.

The high energy electron flux is also expected to start at Normal Background levels, with the posited imminent fast wind from CH93 and an inbound CME significantly increasing uncertainty into the new UTC working week, with an eventual Slight Chance of Active 24-hour integrated fluence as a result.

Figure 1. Solar Analysis Valid 20/1800UTC.



Key: Filament — , Prominence — , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

The dominant consideration for geomagnetic activity is now the large helicoidal filament eruption from the southeast-central disc starting 20/0840UTC. Modelling of this feature has been complicated by a polluting contribution from an almost concurrent nearby and overlapping CME from a prominence eruption around N20E80.

MOSWOC Enlil currently suggests a constant fast wind of near 500km/s in its forecast - with this around 100km/s in error (too fast). This is the rationale for delaying the modelled inbound 20/0840UTC CME a little, from 22/1500 to nearer 22/1800UTC, although the magnitude of this adjustment is approximate. It is likely that this arrival time will be refined over the coming hours as MOSWOC Enlil potentially corrects its overly-fast initial solar wind speed. Also of note is possible interaction between the near-simultaneous prominence and filament eruptions of 20/0840UTC, with the former not yet featuring in the model, but expected to reach 1AU at a similar time, albeit further east.

Earth is otherwise currently sampling a sector of space characterised by a positive phi angle and slight enhancement to the solar wind. This may be the tail of CH92/+, however this is uncertain and in any case has not led to significant geomagnetic activity. There remains one fast wind due in the period: that from CH93/+ during 21 January. Due to the location high in the northern hemisphere and its positive polarity, any response in the solar wind is expected to be muted - perhaps reaching 450-500km/s based on observations from the previous rotations, with these then declining into the new UTC working week.

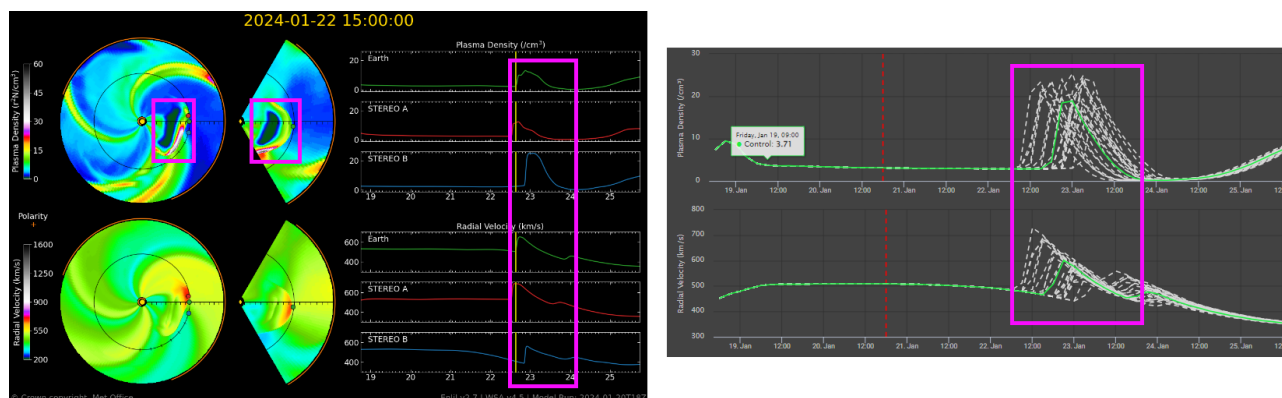
All considered, there is an initial Slight Chance of G1 from the imminent CH93/+ fast wind. This should begin to fade as the inbound 20/0840UTC CME reaches 1AU later in the UTC day of Monday 22 January, with the risk front-loaded but partitioned between this and the following UTC days. G2 is Likely on Monday, with the risk ebbing slightly into the first half of the following UTC day of Tuesday 23 January.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	5	80	50	1
Strong	G3	No	1	30	10	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
20/1302	Partial	Filament	SE disc centre	953	22/1800UTC	Main uncertainty arrival time. Delayed from Enlil suggestions of 20/1500UTC due to erroneous modelled wind.

Figure 2: Latest MOSWOC Enlil run, pasued around the time of arrival of the 20/0840UTC CME, modelled at 20/1500UTC. Because of the initialised solar wind speed near 500km/s instead of the observed 400km/s the CME is likely to reach 1AU too quickly in model space, and this is the rationale for delay to nearer the centre of the ensemble members at 20/1800UTC, although this change is indicative rather than rigorous.



Radio Blackouts - X-Ray Flares:

Solar activity has been Low over the past 24 hours, and remains somewhat below the expectations for the Zurich probabilities of the regions populating the disc. Although there are a large number of regions at present, most of these showed little growth, and those that ran counter to this grew from simple starting points (e.g. AR3562 and AR3560). The one main exception to growth from a low base point was AR3559 in the northeast, which along with a possible new region immediately trailing it at a slightly higher solar latitude, helped to generate the peak flare of the period and may continue to do so given its Eai/Beta classification.

There are no indications of significant returning regions in east limb EUV flux looping at present, and the returning Carrington location of Ex-3534 due in the first 24 hours does not appear to survive to any great extent. In addition, the only departures from the Earth-facing disc are likely to be the unipolar AR3545 and AR3549 during the early part of the coming UTC working week, and these are not likely to offer any significant change to daily risks.

All considered, the daily chances of M-class flares are rated at a Chance, albeit a little below the raw Zurich values for the disc, with this 'regressing to the mean' for this part of the cycle into the new working week given increasing uncertainty with time, and also reflecting the recent slight

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uptick in Penticton 10.7cm flux.

X Ray Flares			Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability	Level	Past 24 Hours (Yes/No)	(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	25	25	30	30
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: SIDC ROB X-ray flares of C-class and above recorded at PROBA2 in the 24 hours to 20/2345UTC. Note that all of the flares can be ascribed to just two sunspot regions, AR3559 (and its possible NEW immediate neighbour) and AR3560. This is the rationale for no decrease in the risk through the period despite two departing regions as these have not contributed in recent days.



Solar Radiation Storms - (High Energy Protons):

GOES18 high energy (greater than 10MeV) proton flux is currently at Background, having shown no response to the long-period C-class flares from the filament and prominence eruptions observed in the period.

There is a daily Slight Chance of rising and reaching the S1 Minor Radiation Storm threshold in response to any notable flares, with this rising slightly in the period as the CME arrives and the more complex regions of the facing side near more favourably-connecting parts of the disc.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	2	5	5	5
Very Active	$\geq \text{S3}$ *	No	1	1	1	1
* S3 $\geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)						

High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) is at Normal Background levels. The only fast wind due in the period ought to arrive inside the current UTC weekend, and provide the main impetus for departure from the current suppressed state of electrons at GEO, however the inbound CME will render electron behaviour in general relatively low confidence in the second half of the four-day period.

Relative to recent guidance, there is a now-increased eventual Slight Chance of Active 24-hour integrated fluence at GEO, however this is as much a statement of increased error bars as it is any expectation for a rise in populations. MOSWOC REFM is not expected to provide a useful steer given the dominance of a transient in the forecast.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	5	10
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1